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Trace Metal Data in Water from Lakes and Streams of the Experimental Lakes Area, Northwestern Ontario, 1976-1986

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Canadian Data Report of

Fisheries and Aquatic Sciences 695

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ABSTRACT

Cruikshank, D., K. Matthisen, and R. Hunt. 1988. Trace metal data in water from lakes and streams in the Experimental Lakes Area, northwestern Ontario, 1976-1986. Can. Data Rep. Fish. Aquat. Sci. 695: v + 255 p.

Trace metal data for four acidified lake basins and several reference lake basins, as well as streams of the Experimental Lakes Area are presented. Analyses for aluminum, copper, iron, manganese and zinc were conducted from 1976 to 1986.

Key words: aluminum; copper; iron; manganese; zinc; acidification.

RÉSUMÉ

Cruikshank, D., K. Matthisen, and R. Hunt. 1988. Trace metal data in water from lakes and streams in the Experimental Lakes Area, northwestern Ontario, 1976-1986. Can. Data Rep. Fish. Aquat. Sci. 695: v + 255 p.

Ce rapport présente des données sur les métaux à l'état de trace applicables à quatre bassins acidifiés ainsi qu'à plusieurs bassins de référence et à des cours dans la Région des Lacs Expérimentaux. Des analyses sur la teneur en aluminium, en cuivre, en fer, en manganèse et en zinc ont été faites de 1976 à 1986.

Mots-clés: aluminium; cuivre; fer; manganèse; zinc; acidification.

INTRODUCTION

Trace metal analyses have been conducted on samples from the Experimental Lakes Area (ELA). Trace metal samples were collected from 6 lake basins and 5 inflows. Four of these lake basins were being experimentally acidified. Samples were analyzed for aluminum, iron, manganese and zinc. Copper was also assayed until early 1985.

This data report presents trace metal analyses for each lake by metal from 1976 to 1986. Figures 2-5 show the concentrations over time of each metal for each lake at a depth of 1 m. Tables 1-5 present the annual mean concentrations of each metal for L114, 223, 302S, 302N and 239 streams for each depth sampled. Miscellaneous lakes are presented in Table 6. Appendices 1-5 show the trace metal depth profiles for each lake for each year the lake was sampled. The Appendix is organized by metal. Dates are expressed as day numbers on the Julian calendar.

Details of lake manipulations are presented by Cruikshank (1984, 1986).

DATA COLLECTION AND METHODS OF ANALYSIS

RINSE WATER PURIFICATION

Water required for rinsing and standard preparation at the Freshwater Institute (FWI) was triple-distilled (TD) in quartz (between 1976 and 1980). From 1981 until present all water for rinsing and analysis was distilled water passed through a Barnstead Ultrapure mixed-bed ion exchange resin column.

The filtering for all years (1976-86) was done in the ELA field chemistry lab. All water used for rinsing, etc. at ELA was distilled water which had passed through a Millipore Super Q water purification system consisting of an ion exchange column, an activated charcoal column and a 0.22 µM filter.

BOTTLE PREPARATION

One-litre round Nalgene bottles (low or high density polyethylene) were used in all years 1976-86. Since May, 1985, 250 mL Nalgene bottles were used to archive unfiltered samples. All new bottles or bottles to be reused from another site underwent a 24 h detergent soak and distilled water rinse prior to the acid washings described below.

From 1976 to 1980, the bottles were soaked (at least overnight) in dilute nitric acid (1.7%), followed by rinsing with TD water, a saturated ethylenediaminetetraacetic acid solution, and TD water. The empty bottles were sealed in polyethylene bags and shipped to the sample site.

From 1981 to 1983, the samples were soaked in 10% nitric acid for at least 24 hours, rinsed with water, sealed in bags, and shipped to the sampling site. No attempt was made to recycle bottles to the same sampling site.

From May 1984 to 1986, in order to reduce cross contamination from different sampling sites, care was taken to reuse the bottles from the same lake and depth. Bottles were emptied, rinsed, and refilled with 0.1% (1984) or 0.5% (1985-86) nitric acid and bagged. New bottles or bottles from a different site were given an additional soak in a mixture of 2% nitric and 2% hydrochloric acid for at least 3 days, rinsed and filled with 0.5% nitric acid until just before sampling.

FIELD SAMPLING

Trace metal water samples were collected using a Masterflex peristaltic pump with silicone rubber pump tubing and sampling lines of Tygon tubing marked off in 1 m intervals. From 1976 to 1982, each trace metal bottle was rinsed and then filled with the pump outlet hose submerged in the bottle. The bottle was then left to overflow for several minutes. Filled bottles were capped and returned to the plastic bag. Samples labelled "EPI" (epilimnion) were usually obtained at a depth of 1 m from the lake's surface. Occasionally, shallower samples were substituted but caution was exercised to exclude any surface film or debris. Water obtained from lake inflows or outflows was labelled IF and OF respectively. These samples were taken by hand dipping the bottles.

Beginning in 1983, in an attempt to minimize sample contamination, the bottles were carried into the field filled with dilute nitric acid (see bottle preparation). They were then emptied prior to sampling, rinsed with water from the depth to be sampled and filled with the pump outlet hose held above the bottle. The hose was not allowed to come in contact with the bottle. Once filled, the bottles were put into a new, clean plastic bag for transport back to the field chemistry lab. Field sampling staff were also cautioned to handle the bottles only when capping and putting them into or out of bags.

These procedures, along with additional precautions taken in the labs, resulted in a dramatic decrease in the number of contaminated samples (Fig. 1). Samples were considered to be contaminated if the reported value exceeded the annual mean by three times the standard deviation of the annual mean for that depth.

FILTERING

All of the one-litre samples were filtered in the ELA field lab prior to analysis. The filtration apparatus, pressurized with nitrogen gas, consisted of a Teflon, 142-mm Millipore unit (Millipore cat. no. YY 4214200) which contained a 127-mm polyethylene filter support. The system was initially cleaned with detergent and dilute nitric acid, but between samples it was rinsed, with the filter in place, with Super Q water followed by approximately 100-200 mL of the sample. The filters, 0.22 µm Millipore,

were soaked in a saturated EDTA solution in covered petri dishes for about 8-12 hours. Then the filters were transferred to another dish and soaked in Super Q water for 4-12 hours before use.

Within 24 hours after collecting, the samples were filtered and then acidified. From 1976 to 1980, 1 L samples were preserved with 2 mL of ultra-pure concentrated nitric acid (Baker Instra-analyzed or acid distilled in a Teflon sub-boiling still). Since 1981, samples had only 1 mL of ultra-pure nitric acid added. At this point they were bagged, sent to the lab in Winnipeg within a week of collection, and kept refrigerated at 4°C until analysis. The interval between sample collection and analysis was usually less than six months and rarely exceeded one year. The duplicate samples taken in 250 mL bottles (since May, 1985) were not filtered or analyzed. These samples were acidified (0.1% HNO_3) within 24 hours and sent to Winnipeg where they were frozen at -40°C. These samples, as well as selected 1 L filtered samples from 1984, were archived.

ANALYSIS

Instrumentation

Over the course of the study, three instrumental techniques were employed for metals analysis.

A. Graphite furnace atomic absorption spectrophotometry (GFAA) using one of three instruments: 1. Varian Techtron AA-5 with a CRA 90 carbon rod atomizer (GFAA-5); 2. Perkin Elmer 403 with an HGA 2100 graphite furnace (GFAA-PE); 3. Varian 975 with a GTA-95 graphite furnace (GFAA-975).

B. Air acetylene flame atomic absorption spectrophotometry using a Varian Techtron AA-5 (FAA).

C. Direct current argon plasma emission spectrometry using a Spectrametrics Spectraspan IIIB with 1000 mg/L Cs ionization buffer in both samples and standards (DCP).

Methods

From 1976 to 1980, GFAA-PE was the main analytical technique. FAA was used to determine iron and manganese when concentrations exceeded GFAA working range.

From 1981 until 1984, a method for concentrating the samples by 20 times was employed. Acid-washed, 250 mL Teflon beakers were filled with 200 mL of sample and left on a hotplate (Corning PC 100) overnight, or until dry, at a temperature just below boiling (≈60°C). When dry, 2 mL of purified nitric acid was added and the beakers were returned to the hotplate. Care was taken to wash down the beaker walls during each step. Then 1 mL of 50% hydrogen peroxide was added. When effervescence ceased (oxidation complete), 200 µL of hydrochloric acid was added and heated until a pale yellow colour was obtained. To conclude the concentration procedure, 3 or 4 mL of distilled deionized water was added, the solution was transferred to a 10 mL volumetric flask and made up to volume with deionized water.

Concentrated samples were analyzed for manganese, iron and aluminum by DCP. Zinc and copper were analyzed by FAA. For verification, the samples were analyzed directly (unconcentrated) by GFAA-5 (1981-82). For the years 1983-84, samples were checked directly by GFAA-975.

For samples from the years 1985 to 1986, manganese, iron and aluminum were initially analyzed by DCP on the unconcentrated waters. Elements with concentrations below 75 $\mu g \cdot L^{-1}$, and all copper and zinc were then analyzed by GFAA-975.

The sensitivty of GFAA analysis for Zn was found to increase in the presence of phosphate ions. This effect was normalized by the addition of phosphoric acid (5 µL of 0.02% with each injection) to both standards and samples.

QUALITY CONTROL

Concentrated samples analyzed by DCP

Starting in October, 1982, a quality control sample (QC) was concentrated and analyzed with each set of 24 ELA samples. This QC was made up in the FWI lab by adding known amounts of standards to 20 L of distilled deionized water. Each batch of QC would last for approximately one year. The target concentrations of each metal were changed with each new batch to more closely approximate the actual values in the ELA waters. The calculated value of each concentrated QC was compared to the target value and used to determine whether re-analysis of the samples was necessary.

A second reason for analyzing a QC was to determine both method and instrument variability from day to day. This was achieved by recording the calculated value for each metal of the QC analyzed with every set of samples. The mean and standard deviation of each metal is tabulated in Table 7. Four different QC batches are reported with their corresponding target values.

Samples analyzed directly by GFAA

Starting in September, 1984, one batch of QC was analyzed directly by GFAA-975). A QC was analyzed with each run of ELA waters. The means and standard deviations of analyses performed between September, 1984 and May, 1986 are summarized in Table 8.

From July, 1986, a reference water sample (SLRS-1) from the National Research Council of Canada (NRC) was used to monitor (GFAA-975) instrument variability. These results are also found in Table 8. NRC gives the reference material values and 95% tolerance limits for each metal. These reference values were based on determinations by at least three independent methods of analysis (for copper and zinc by five and six methods respectively). Direct determin-

ation by GFAA was one of the methods used for each of the five metals.

Inter-laboratory comparison

During July, 1986, total aluminum was analyzed in water samples provided for LRTAP Interlaboratory Study No. L-13 . A summary of the results of FWI's input are found in Table 9. Subsamples of the series of unpreserved water were acidified to 0.5% HNO_3 before analysis by GFAA. DCP was also used but only for concentrations over 100 $\mu g \cdot L^{-1}$. For further information on the intercomparison study, refer to the pre-published draft summary report by K.I. Aspila, LRTAP Interlaboratory Study No. L-13: Aluminum in Water, October 1986, Quality Assurance and Methods Section, Analytical Methods Division, National Water Research Institute, P.O. Box 5050, Burlington, Ontario, L7R 4A6.

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CRUIKSHANK, D.R. 1986. Whole lake chemical additions in the Experimental Lakes Area, 1984-1985. Can. Data Rep. Fish. Aquat. Sci. 580: iv + 10 p.

Table 1a. L114 annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Al.

Year/Depth	1 m	3 m	4 m	5 m	OF	pH
1978	37.6 ± 31.3		35.5 ± 33.5	36.7 ± 33.1	47.7 ± 28.4	6.18
1979	28.9 ± 14.7		42.9 ± 25.1	40.7 ± 25.1		5.82
1980	29.1 ± 18.6		29.9 ± 14.8	41.1 ± 29.5		6.11
1981	29.2 ± 12.3	23.1 ± 8.7	42.6 ± 24.8	28.2 ± 9.3	47.5 ± 15.7	6.05
1982	37.2 ± 19.8	37.9 ± 20.8	44.9 ± 27.2			5.90
1983	26.4 ± 20.9	28.0 ± 19.6	32.9 ± 27.2			5.94
1984	22.3 ± 20.9	23.4 ± 21.9	27.1 ± 24.1			5.65
1985	48.3 ± 24.7					5.88
1986	31.2 ± 28.5					6.26

Table 1b. L223 annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Al.

Year/Depth	1 m	4 m	8 m	10 m	11 m	12 m	13 m	14 m	IF	OF	pH
1976	6.4± 5.2	6.9± 5.1	6.6± 3.6			5.7± 3.9		8.3± 5.4			6.49
1977	12.3±12.2	17.5±26.3	15.0±26.8			15.0±23.2		26.6±26.6	67.6±35.5	9.9± 3.8	6.13
1978	28.2±16.7	27.6±20.8	29.3±22.0			27.3±23.4		74.0±56.8	35.5±19.5	33.8±13.6	5.93
1979	23.2±10.3	19.9± 7.5	18.9± 9.7	18.6± 8.6	18.8± 7.3	34.6±30.4	49.7±29.3	78.3±35.9	35.4±15.5	27.2±10.8	5.64
1980	21.2±10.6	22.1± 8.0	19.0±10.2	18.7± 8.9	16.2± 7.5	16.6± 9.7	35.9±19.8	55.8±44.6	35.4±18.3	27.5± 7.5	5.59
1981	32.7±16.0	33.0±17.9	22.0± 8.7	24.2±12.2	21.9±13.3	23.0±15.2	24.5±11.6	44.3±36.2	68.8±22.1	30.0±12.6	5.02
1982	38.8±13.3	40.2±15.5	29.6±17.1	23.6±13.0	29.1±16.1	26.8±13.9	33.4±17.1	43.5±17.2	41.0±19.1		5.09
1983	19.9± 9.0	20.8± 8.5	17.9± 8.5	14.9± 7.5	11.9± 4.5	13.8± 7.0	18.8± 9.2	32.4±32.2	22.1±10.3		5.13
1984	12.9± 4.8	11.8± 4.5	13.5± 5.3	12.3± 5.3	12.4± 7.2	11.2± 4.9	14.6± 4.4	27.6±12.7	51.9±10.6		5.44
1985	28.9±12.6	26.6±11.2	22.0± 8.5	18.7± 8.9		30.4±11.1		47.0±12.5	21.9± 9.6		5.53
1986	19.5±10.1	19.0± 9.5	18.6± 9.4	19.6± 8.5		22.2±10.4		43.6±24.5	21.5± 8.0		5.45

OF = outflow
IF = inflow

Table 1c. L302N annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Al.

Year/Depth	1 m	4 m	6 m	8 m	9 m	10 m	11 m	13 m	pH
1980	6.6± 2.6	6.0± 2.1	10.0± 6.6		14.9± 9.9		30.3±21.4	15.2± 5.4	6.18
1981	10.7± 8.7	8.7± 4.9	10.5±11.5	12.5± 5.1	9.9± 3.6	17.7±12.5	15.4±16.3	33.6±26.6	6.43
1982	14.8± 8.1	13.8± 6.8	13.7± 5.9	18.3±12.1	17.0± 4.9	29.0±23.3	34.7±31.9	47.1±27.5	6.71
1983	10.4± 4.7	11.4± 5.4	10.3± 5.1	12.1± 5.3	12.6± 4.8	17.9±10.9	24.7±15.3	38.4±18.3	6.34
1984	8.3± 4.1	8.0± 4.4	8.3± 4.3	8.9± 3.9	9.5± 3.8	10.6± 6.6	13.1± 8.2	25.8±11.8	6.24
1985	16.0±12.2	17.6±10.7	15.8± 8.7		19.8± 9.1		23.6±11.2	36.8±10.6	6.02
1986	18.0± 9.7	17.9± 9.8	19.9± 9.2		24.5±11.8		32.3±16.6	44.6±24.9	5.98

Table 1d. L302S annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Al.

Year/Depth	1 m	4 m	6 m	7 m	8 m	9 m	10 m	pH
1980	6.0± 2.3	5.1± 1.5	6.6± 3.1		8.5±3.9		9.5± 3.1	6.52
1981	8.6± 6.0	8.1± 9.1	9.8±11.0	9.0±6.4	9.2±5.0	6.8±3.3		6.75
1982	9.9± 4.4	12.0± 8.3	12.4± 7.4	10.5±5.5	9.8±4.2	9.1±4.7	15.7±11.2	6.25
1983	7.5± 5.3	8.7± 5.6	8.4± 5.9	8.5±6.6	9.2±5.4	10.5±5.4	16.2±15.0	5.86
1984	7.3± 4.7	8.0± 5.6	9.1± 6.1	9.0±6.0	10.6±6.4	13.2±8.1	48.2±48.8	5.60
1985	33.2±13.4	31.8±12.8	27.8±10.3		25.7±7.3		34.6± 9.0	5.31
1986	33.2± 9.4	31.5± 8.6	29.3± 8.1		25.4±7.7		38.6±21.2	5.02

Table 1e. L239 annual mean heavy metal concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Al.

Year/Depth	1 m	5 m	10 m	15 m	20 m	25 m	30 m
1985	44.6±7.9	46.9± 8.8	41.9±4.7	40.6±2.8	38.1±4.0	41.4± 6.3	52.1±10.9
1986	41.8±9.4	35.6±13.2	42.9±6.1	45.8±9.2	48.4±9.1	55.0±11.5	64.8±12.1

Table 1f. L239 streams annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Al.

Year/stream	NWIF	EIF	OF	NEIF	NE @ 239
1978	439±148	298.7± 76	79.1±13.0	339± 84	
1979	311±105	199.3±106	64.8±12.9	351±104	
1980	263± 74	190.3± 48	50.4±11.9	464±109	
1981	264±125	175.0± 84	35.4±19.2	290± 88	
1982	277±102	189.6± 66	28.1± 6.9	240± 96	
1983	248± 80	180.0± 92	25.8± 7.7	261±155	
1984	305± 94	232.3± 67	20.0± 3.4	314± 67	
1985	320±122	253.0± 69	43.5±10.4	270±106	
1986	366±107	253.0± 71	42.9± 7.3	452±217	614±235

NWIF = northwest inflow
EIF = east inflow
OF = outflow
NEIF = northeast inflow at weir
NE @ 239 = northeast inflow at lake entry

Table 2a. L114 annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Cu.

Year/Depth	1 m	3 m	4 m	5 m	OF	pH
1978	1.9 ± 1.3		1.7 ± 1.0	3.2 ± 1.6	2.1 ± 1.7	6.18
1979	1.3 ± 1.2		1.8 ± 1.4	1.5 ± 1.3		5.82
1980	1.2 ± 2.0		1.3 ± 2.3	1.8 ± 2.2		6.11
1981	1.5 ± 1.2	1.2 ± 1.1	0.8 ± 0.6	0.8 ± 0.6	1.5 ± 1.3	6.05
1982	1.9 ± 0.9	1.4 ± 0.8	2.0 ± 0.8	1.7 ± 0.9	2.9 ± 1.9	5.90
1983	1.7 ± 1.3	1.4 ± 1.0	1.4 ± 1.1			5.94
1984	1.1 ± 0.8	0.8 ± 0.4	0.9 ± 0.4			5.65
1985			Cu analysis discontinued			5.88
1986			Cu analysis discontinued			6.26

OF = outflow

Table 2b. L223 annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Cu.

Year/Depth	1 m	4 m	8 m	10 m	11 m	12 m	13 m	14 m	IF	OF	pH
1976	0.8±0.5	1.0±0.7	0.7±0.6			0.8±0.7		1.5±1.4		1.1±0.7	6.49
1977	0.8±0.6	0.9±0.6	0.6±0.3			0.8±0.7		1.7±1.2	1.2±0.8	0.8±0.7	6.13
1978	1.3±1.0	0.9±1.0	1.0±0.9			0.9±1.1		2.2±1.4	0.9±0.9	0.9±0.8	5.93
1979	0.8±0.8	0.7±0.6	0.7±0.7	0.7±0.7	0.4±0.2	0.5±0.2	1.8±2.8	2.1±2.3	0.9±1.4	0.7±0.6	5.64
1980	1.0±1.2	0.8±0.5	0.7±0.8	0.7±0.7	0.5±0.3	0.9±1.5	1.5±1.5	3.1±2.1	0.6±0.5	0.7±0.6	5.59
1981	1.4±1.5	1.3±1.7	0.9±0.8	1.3±2.0	1.2±1.7	0.8±1.2	1.8±2.4	2.0±2.7	0.8±0.7	0.8±0.8	5.02
1982	1.8±1.4	2.2±1.7	2.5±1.8	1.5±0.7	1.5±0.9	3.1±2.7	2.6±2.4	1.8±0.9	1.2±0.9		5.09
1983	1.6±1.2	1.4±1.1	1.5±1.2	1.4±1.1	1.4±1.3	2.0±1.5	1.4±0.7	1.3±1.1	1.4±1.4		5.13
1984	0.8±0.5	0.8±0.4	1.1±0.8	0.7±0.3	1.0±1.1	0.6±0.4	0.7±0.5	1.0±1.0	1.3±0.5		5.44
1985					Cu analysis discontinued						5.53
1986					Cu analysis discontinued						5.45

OF = outflow
IF = inflow

Table 2c. L302N annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Cu.

Year/Depth	1 m	4 m	6 m	8 m	9 m	10 m	11 m	13 m	pH
1980	1.1± 1.5	0.5± 0.4	0.7± 0.4		0.6± 0.4		0.5±0.4	1.2± 1.5	6.18
1981	1.4± 1.1	1.1± 0.6	0.9± 0.9	1.3± 0.9	1.5± 1.5	0.9± 0.8	1.3±1.3	2.4± 2.5	6.43
1982	1.3± 0.5	1.9± 1.7	1.2± 0.6	1.8± 2.1	1.2± 0.8	1.0± 0.6	1.3±0.6	1.6± 1.5	6.71
1983	1.9± 1.1	1.9± 1.2	1.9± 2.1	1.3± 0.5	2.1± 2.2	1.7± 1.5	1.5±1.8	2.0± 2.2	6.34
1984	1.1± 0.7	1.1± 0.6	0.8± 0.5	0.9± 0.5	1.3± 1.1	0.9± 0.7	1.0±0.9	0.8± 0.6	6.24
1985				Cu analysis discontinued					6.02
1986				Cu analysis discontinued					5.98

Table 2d. L302S annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Cu.

Year/Depth	1 m	4 m	6 m	7 m	8 m	9 m	10 m	pH
1980	0.5±0.2	0.4±0.2	0.6±0.4		0.5±0.3		0.8±0.6	6.52
1981	0.5±0.3	1.5±1.3	0.7±0.5	0.6±0.4	0.6±0.5	0.8±0.9	0.7±0.5	6.75
1982	1.7±1.9	1.5±0.9	1.5±0.9	2.0±1.4	2.2±2.4	1.4±0.7	1.8±1.5	6.25
1983	1.3±0.9	1.6±1.4	1.6±1.8	0.9±0.3	1.3±0.6	1.2±0.4	1.0±0.4	5.86
1984	0.8±0.5	0.8±0.4	1.0±0.6	1.0±0.6	1.1±0.6	1.0±0.5	1.0±0.6	5.60
1985	Cu analysis discontinued							5.31
1986	Cu analysis discontinued							5.02

Table 2e. L239 streams annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Cu.

Year/stream	NWIF	EIF	OF	NEIF	NE @ 239
1978	1.8±1.8	2.2±2.2	1.5±0.5	2.3±1.5	
1979	1.5±0.9	1.1±0.8	0.7±1.4	2.4±2.5	
1980	0.8±0.6	0.9±0.6	0.7±1.3	2.6±1.9	
1981	2.0±2.0	1.7±1.7	1.5±0.4	2.3±1.8	
1982	1.9±2.0	1.5±1.0	1.6±1.2	2.2±1.2	
1983	2.0±1.1	1.8±0.9	1.8±1.1	2.9±1.4	
1984	1.6±1.6	1.3±1.2	0.7±0.3	1.7±1.0	
1985	Cu analysis discontinued				
1986	Cu analysis discontinued				

NWIF = northwest inflow
EIF = east inflow
OF = outflow
NEIF = northeast inflow at weir
NE @ 239 = northeast inflow at lake entry

Table 3a. L114 annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Fe.

Year/Depth	1 m	3 m	4 m	5 m	OF	pH
1978	18.3 ± 17.5		74.4 ± 114	156 ± 244	109 ± 135	6.18
1979	28.1 ± 50.6		1249 ± 375	1306 ± 3473		5.82
1980	23.1 ± 40		2195 ± 4303	4175 ± 6894		6.11
1981	50.8 ± 61	651 ± 1458	2483 ± 4540	1287 ± 2947	212 ± 221	6.05
1982	31.3 ± 34	510 ± 1356	2127 ± 4176			5.90
1983	24.6 ± 29.4	623 ± 1810	1634 ± 3812			5.94
1984	41.6 ± 58.7	1757 ± 3123	2504 ± 3779			5.65
1985	74.9 ± 104					5.88
1986	38.0 ± 27					6.26

OF = outflow

Table 3b. L223 annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Fe.

Year/Depth	1 m	4 m	8 m	10 m	11 m	12 m	13 m	14 m	IF	OF	pH
1976	15.3±11.9	14.2± 8.9	26.1±20.5			41.1±19.7		2700±5166			6.49
1977	12.7±13.4	11.8± 9.3	16.4±18.4			667.6±1550		10012±11026	221.2± 158	18.5± 6.6	6.13
1978	9.3± 7.1	10.9±12.6	12.6± 8.7			1648±2990		12318± 9862	64.1± 44	19.8± 12.3	5.93
1979	11.6± 6.9	13.3± 7.8	15.4± 8.1	27.1± 15.2	44.1±28.6	1662±2318	5265±5174	16112±16053	114.9± 91.7	33.3± 22.3	5.64
1980	21.2±17.1	22.3±23.6	22.6±22.2	53.1± 29.7	83.6±50.3	1864±3116	6493±5605	22923±15656	321.7±130.1	61.0± 28.9	5.59
1981	28.8± 9.0	25.4±12.1	31.0±15.5	43.7± 22.2	66.2±30.0	726±1122	3848±4643	7397± 9658	427.5± 298	135.6±167.9	5.02
1982	59.2±47.8	47.4±55.3	49.1±48.5	111.8±153.5	1067±1875	1694±2332	3833±4053	8282± 7978	105.3± 73.5		5.09
1983	26.4±12.1	28.6±12.5	32.8±17.2	70.0± 75.6	95.9±74.4	1169±1499	2538±2635	6376± 6709	139.4± 87.8		5.13
1984	24.0±12.8	24.3±12.1	31.3±16.4	35.4± 17.1	39.9±24.1	1181±1959	3767±3525	7615± 6605	291.3±127.6		5.44
1985	30.5±26.7	23.9±20.6	35.4±20.3	653.5± 1098		3052±2347		7895± 5531	57.9± 28.3		5.53
1986	23.6±16.8	27.1±16.2	41.3±12.9	341.7± 824		1616±2250		5725± 6590	244.8± 199		5.45

OF = outflow
IF = inflow

Table 3c. L302N annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Fe.

Year/Depth	1 m	4 m	6 m	8 m	9 m	10 m	11 m	13 m	pH
1980	13.2± 6.0	9.2± 1.8	19.6±12.3		24.8±14.8		2021±2172	2451±2541	6.18
1981	9.8± 8.6	7.9± 3.7	10.0± 7.1	24.3±19.0	62.9±57.9	442±1095	705±1170	5439±7831	6.43
1982	12.7±11.9	16.2±14.6	16.2± 8.9	41.1±26.2	128±136	824±1144	1326±1535	3191±2239	6.71
1983	9.2± 7.0	12.4±10.0	15.4±12.5	36.6±29.5	44.6±23.7	922±1385	1626±1780	3684±2815	6.34
1984	8.4± 6.4	9.0± 6.2	12.5± 5.8	23.8±14.7	82.5±148	510±996	947±1223	3523±2784	6.24
1985	16.6±15.1	21.0±15.1	39.7±21.3		673±1030		1314±1426	3141±2241	6.02
1986	21.4±17.2	20.9±16.0	31.6±15.2		364±662		1565±1513	3695±4530	5.98

Table 3d. L302S annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Fe.

Year/Depth	1 m	4 m	6 m	7 m	8 m	9 m	10 m	pH
1980	8.1± 2.2	7.5± 3.0	16.0±11.7		51.0±41.3		4389±5970	6.52
1981	12.5±12.5	13.4±15.4	33.0±34.8	28.5±18.4	109±94.5	112.1±106	3010±4840	6.75
1982	13.9±12.2	16.3±11.6	23.7±20.7	56.7±51	125±103	231.1±304	1631±2441	6.25
1983	13.0± 7.5	15.4± 9.5	20.1±19.9	57.9±40.0	97±55	533.3±1090	1615±3025	5.86
1984	17.6±12.6	22.7±17.9	47.5±41.3	69.6±60.8	286±779	1505±855	6902±8452	5.60
1985	27.8±14.4	29.6±17.9	59.2±47.4		113±74		2502±2865	5.31
1986	57.1±23.0	51.7±20.3	73.5±30.7		409±865		2153±2466	5.02

Table 3e. L239 annual mean heavy metal concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Fe.

Year/Depth	1 m	5 m	10 m	15 m	20 m	25 m	30 m
1985	16.4±4.6	18.1±7.8	17.0±6.1	15.0±7.8	18.1± 6.6	36.4±13.7	85.3±49.7
1986	14.0±8.1	13.6±7.5	16.4±7.3	20.4±6.3	28.6±10.1	63.6±31.5	113.4±59.0

Table 3f. L239 streams annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Fe.

Year/stream	NWIF	EIF	OF	NEIF	NE @ 239
1978	613±244	671±278	22.5± 6.6	1084±397	
1979	346± 93	339±110	25.7± 7.4	571± 93	
1980	349±125	515±167	16.8± 9.5	962±262	
1981	397±283	373±181	16.8±10.2	585±187	
1982	356±222	355±139	19.4±13.6	426±174	
1983	337±174	304±160	15.2± 6.6	482±267	
1984	340±184	301±105	18.4±12.4	540±162	
1985	329±150	364±118	16.4± 7.9	472±164	
1986	458±179	366± 94	20.3±12.8	864±403	927±407

NWIF = northwest inflow
EIF = east inflow
OF = outflow
NEIF = northeast inflow at weir
NE @ 239 = northeast inflow at lake entry

Table 4a. L114 annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Mn.

Year/Depth	1 m	3 m	4 m	5 m	OF	pH
1978	10.5 ± 7.6		10.0 ± 2.9	10.8 ± 3.9	27.8 ± 16.9	6.18
1979	21.6 ± 10.2		31.6 ± 16.3	46.7 ± 18.6		5.82
1980	20.6 ± 25.5		62.6 ± 77.9	83.4 ± 92.9		6.11
1981	25.4 ± 34.0	47.8 ± 57.6	66.2 ± 75.9	58.4 ± 67.7	42.6 ± 30	6.05
1982	15.7 ± 14.9	38.4 ± 48.2	49.7 ± 61.6			5.90
1983	14.8 ± 18.4	45.6 ± 65.6	59.1 ± 85.5			5.94
1984	15.8 ± 18.6	38.0 ± 83.9	91.1 ± 114			5.65
1985	25.1 ± 25.6					5.88
1986	12.3 ± 3.2					6.26

OF = outflow

Table 4b. L223 annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Mn.

Year/Depth	1 m	4 m	8 m	10 m	11 m	12 m	13 m	14 m	IF	OF	pH
1976	7.1± 8.3	6.5± 8.6	7.4± 7.9			148.5± 145		284.2± 282		12.9±10.0	6.49
1977	32.8±22.8	36.1±23.2	44.7±28.3			174.1± 102		663.2± 481	18.8±12.8	26.8± 6.1	6.13
1978	64.9±16.9	66.6±26.5	95.9±27.1			323.5± 210		583± 263	9.2± 3.4	57.2±16.9	5.93
1979	89.7±33.1	87.1±15.5	95.7±39.8	133.3±46.9	170.0±81.9	345.6± 230	452.2± 281	674.4± 450	29.7±28.2	73.7±22.1	5.64
1980	125.7±	113.3±38.9	116.0±37.2	128.1±34.6	179.1±94.7	243.1± 135	300.1± 135	481.3± 170	37.6±15.4	92.9±27.6	5.59
1981	189.7±59.3	188.7±61.6	180.6±60.9	185.6±60.6	235.6± 108	237.3± 103	274.8± 109	315.6± 130	25.9±12.0	189.0±17.9	5.02
1982	170.8±35.3	186.4±26.9	192.7±24.9	215.5±55.9	244.6±76.5	227.3±47.3	254.6±62.8	313.6± 117	7.8± 4.5		5.09
1983	158.9±16.2	164.6±15.7	164.6±15.7	169.1±23.0	187.3±30.0	197.3±40.3	215.5±46.1	278.2± 121	15.3±10.9		5.13
1984	122.9±25.0	131.8±27.0	146.7±34.2	145.8±33.7	168.3±44.8	176.7±48.3	202.8±65.6	268.2±96.1	20.8±19.1		5.44
1985	84.9±20.2	88.6±22.2	118.9±30.1	146.4±53.4		156.6±46.1		222.0±80.8	3.8± 2.0		5.53
1986	77.8± 8.2	78.1± 7.2	80.4± 5.5	121.5±51.1		147.9±61.3		206.2±94.5	20.2±16.4		5.45

OF = outflow
IF = inflow

Table 4c. L302N annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Mn.

Year/Depth	1 m	4 m	6 m	8 m	9 m	10 m	11 m	13 m	pH
1980	7.5± 6.3	4.9± 2.6	46.2±52.9		198±238		357±349	371± 389	6.18
1981	4.1± 4.8	4.4± 6.8	6.6±11.7	88.6± 98	202±224	268±261	370±284	925±1134	6.43
1982	9.8±13.5	6.7± 9.0	18.6±13.3	118±122	191±186	274±192	332±151	820± 527	6.71
1983	17.5±22.4	20.4±26.5	23.1±27.5	111±106	201±191	287±273	385±228	683± 367	6.34
1984	16.5±18.3	19.4±20.1	21.6±21.1	104±119	222±213	297±225	390±215	609± 323	6.24
1985	39.4±34.9	45.8±28.8	84.1±36.3		243±207		307±189	558± 373	6.02
1986	47.0±26.8	47.9±31.1	62.4±27.3		239±225		306±203	509± 508	5.98

Table 4d. L302S annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Mn.

Year/Depth	1 m	4 m	6 m	7 m	8 m	9 m	10 m	pH
1980	6.7± 4.9	2.2± 1.6	12.8±17.3		285.7±381		602.0±620	6.52
1981	7.1± 8.8	9.4±14.7	28.7±32.3	28.6±31.3	145.1±122	245.9±309	620.3±514	6.75
1982	17.2±10.7	13.8±12.3	20.4±13.4	51.0±35.8	123.5±72.3	284.2±239	452.9±357	6.25
1983	44.6±14.2	46.8±13.3	57.8±18.3	80.8±32.7	114.4±47.9	243.7±219	303.5±227	5.86
1984	79.8±11.8	79.0±11.7	94.2±17.0	101.9±23.8	103.2±24.4	183.5±125	479.6±457	5.60
1985	108.8±31.5	112.7±30.9	115.3±30.2		170.3±77.8		220.0±86	5.31
1986	155.3±17.5	156.4±13.6	158.2±17.2		172.7±42.2		198.2±41	5.02

Table 4e. L239 annual mean heavy metal concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Mn.

Year/Depth	1 m	5 m	10 m	15 m	20 m	25 m	30 m
1985	2.4±1.9	3.7±3.5	5.5±2.6	4.5±2.3	5.1±3.3	7.4±5.5	26.9±29.4
1986	1.6±1.3	1.7±1.6	3.0±1.1	3.4±2.2	4.1±2.4	9.0±9.1	26.2±21.9

Table 4f. L239 streams annual mean concentrations and standard deviatio ($\mu g \cdot L^{-1}$) for Mn.

Year/stream	NWIF	EIF	OF	NEIF	NE @ 239
1978	17.2± 4.1	28.3±14.7	2.1±6.0	83.6±19	
1979	16.7± 7.9	21.8±23.8	2.2±2.0	74.7±30	
1980	28.7±12.5	41.0±22.5	3.0±2.5	65.0±18	
1981	22.6± 9.0	18.5±10.2	1.9±3.8	43.1±12	
1982	12.9± 3.5	9.4± 5.2	1.1±1.5	35.4±14	
1983	17.5± 6.5	9.8± 5.2	1.7±1.8	42.4±25	
1984	16.3± 6.7	11.2±12.5	2.3±1.5	45.9±11	
1985	14.8± 8.5	10.3± 9.5	1.7±1.6	41.6±14	
1986	13.1± 4.6	4.6± 2.0	1.6±1.6	38.3±13	53.9±11.7

NWIF = northwest inflow
EIF = east inflow
OF = outflow
NEIF = northeast inflow at weir
NE @ 239 = northeast inflow at lake entry

Table 5a. L114 annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Zn.

Year/Depth	1 m	3 m	4 m	5 m	OF	pH
1978	3.8 ± 1.8		3.1 ± 1.7	3.2 ± 1.4	3.1 ± 1.8	6.18
1979	3.8 ± 2.3		3.8 ± 3.1	1.6 ± 0.8		5.82
1980	2.0 ± 1.4		2.9 ± 2.6	1.8 ± 1.2		6.11
1981	3.0 ± 1.7	2.3 ± 1.4	2.4 ± 1.7	2.2 ± 1.6	4.0 ± 2.0	6.05
1982	4.2 ± 2.2	3.2 ± 1.4	3.0 ± 1.4			5.90
1983	2.7 ± 1.2	3.0 ± 1.8	2.6 ± 1.5			5.94
1984	2.0 ± 1.5	2.0 ± 1.5	2.2 ± 1.3			5.65
1985	3.1 ± 2.2					5.88
1986	3.4 ± 2.1					6.26

Table 5b. L223 annual mean concentrations and standard deviation ($ug \cdot L^{-1}$) for Zn.

Year/Depth	1 m	4 m	8 m	10 m	11 m	12 m	13 m	14 m	IF	OF	pH
1976	1.5±1.2	1.5±0.9	2.2±1.3			1.9±1.5		1.3±0.9		3.2±3.6	6.49
1977	4.0±1.9	4.4±2.3	3.4±1.7			4.0±1.9		3.2±1.4	5.3±2.4	4.7±1.9	6.13
1978	4.3±2.2	2.8±1.1	3.1±1.6			2.9±1.5		2.0±0.9	2.7±1.8	3.7±2.1	5.93
1979	3.8±2.2	3.5±2.3	3.1±1.7	2.9±1.5	2.4±1.1	2.5±1.3	1.6±1.6	2.8±2.5	3.7±2.5	4.2±1.3	5.64
1980	4.1±2.9	3.1±1.1	2.7±2.1	1.8±1.1	2.8±2.1	2.8±2.0	3.0±2.3	3.4±3.0	4.8±2.7	4.5±2.4	5.59
1981	5.4±3.2	4.7±2.9	3.7±2.2	3.1±2.9	2.9±2.5	3.0±2.9	3.4±2.6	4.5±2.4	6.3±2.2	7.3±2.6	5.02
1982	8.2±2.2	8.1±3.5	8.1±2.7	7.2±5.2	6.0±3.6	7.1±4.0	6.4±3.3	6.3±3.7	5.1±3.2		5.09
1983	4.5±1.1	4.1±1.0	3.9±0.9	3.5±1.3	3.2±1.2	2.7±0.9	2.3±0.9	2.8±1.7	1.1±0.6		5.13
1984	3.4±1.4	3.1±1.3	3.5±1.1	2.8±0.9	3.2±2.0	2.3±1.2	2.0±0.8	2.9±1.8	2.1±0.7		5.44
1985	2.2±1.6	1.7±1.1	1.6±0.8	1.7±0.7		1.8±1.3		1.7±1.6	0.7±0.3		5.53
1986	3.5±1.5	2.2±0.8	2.4±1.4	2.5±1.4		1.9±1.7		1.7±1.2	2.1±1.0		5.45

OF = outflow
IF = inflow

Table 5c. L302N annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Zn.

Year/Depth	1 m	4 m	6 m	8 m	9 m	10 m	11 m	13 m	pH
1980	1.0±0.9	0.4±0.9	0.8±0.5		1.0±0.5		0.9±0.6	1.1±1.0	6.18
1981	1.5±0.7	1.6±1.3	1.6±1.4	2.7±1.8	2.0±1.0	2.1±0.5	2.1±1.0	3.0±1.4	6.43
1982	3.4±6.4	2.3±1.1	2.0±1.1	2.1±0.7	2.1±0.7	2.1±1.0	2.4±0.7	2.6±1.0	6.71
1983	1.6±1.0	1.7±1.0	1.5±1.1	1.5±0.3	2.0±1.2	1.7±1.0	2.3±1.7	2.6±1.7	6.34
1984	1.8±2.1	1.4±1.2	1.2±1.2	1.3±0.8	1.9±1.1	1.2±0.7	1.3±0.7	1.7±1.2	6.24
1985	1.4±0.7	1.2±1.0	1.3±0.6		1.1±0.5		1.5±0.9	1.2±0.7	6.02
1986	2.3±1.1	1.8±1.1	1.8±0.7		2.4±1.3		1.9±0.9	2.0±1.2	5.98

Table 5d. L302S annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Zn.

Year/Depth	1 m	4 m	6 m	7 m	8 m	9 m	10 m	pH
1980	0.7±0.7	0.7±0.8	0.5±0.3		0.9±0.7		1.3±1.5	6.52
1981	1.9±1.4	1.8±1.7	1.7±1.5	2.7±1.9	1.9±1.1	1.9±1.1	1.5±1.4	6.75
1982	2.9±1.7	2.3±0.9	2.9±1.1	3.1±2.1	1.8±1.0	2.0±0.8	2.6±1.2	6.25
1983	2.6±1.7	2.2±0.7	2.3±0.8	2.2±0.7	2.1±0.7	1.7±0.8	1.7±1.0	5.86
1984	2.6±1.6	1.6±0.7	2.3±1.7	2.2±1.3	2.3±1.1	1.8±0.9	2.8±1.3	5.60
1985	2.2±0.8	2.1±1.4	1.8±0.8		1.9±0.9		3.4±3.3	5.31
1986	5.2±1.8	3.8±0.9	4.3±1.5		3.2±1.4		2.8±1.6	5.02

Table 5e. L239 annual mean heavy metal concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Zn.

Year/Depth	1 m	5 m	10 m	15 m	20 m	25 m	30 m
1985	1.2±0.6	1.2±0.6	1.3±0.8	1.0±0.5	1.1±0.4	1.4±1.1	1.6±1.3
1986	1.9±1.0	1.3±0.6	2.0±0.7	2.0±1.2	1.9±1.1	2.1±1.7	2.2±1.1

Table 5f. L239 streams annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$) for Zn.

Year/stream	NWIF	EIF	OF	NEIF	NE @ 239
1978	4.4±1.9	4.7±1.6	3.0±0.7	11.0±4.8	
1979	4.9±3.4	4.7±2.5	4.1±2.1	9.3±3.6	
1980	3.0±1.7	3.1±1.7	0.9±2.3	9.4±5.2	
1981	3.7±1.9	3.3±2.0	2.2±2.6	7.6±4.6	
1982	2.8±1.1	2.6±1.3	1.6±1.1	7.0±2.6	
1983	2.8±1.7	2.3±1.2	1.5±1.2	7.1±3.6	
1984	2.0±1.2	3.4±1.5	0.6±0.3	7.7±1.6	
1985	1.8±1.3	3.3±2.1	1.6±2.3	6.9±4.5	
1986	2.6±0.7	5.2±2.1	2.9±2.0	11.6±4.4	7.4±1.1

NWIF = northwest inflow
EIF = east inflow
OF = outflow
NEIF = northeast inflow at weir
NE @ 239 = northeast inflow at lake entry

Table 6. Miscellaneous lakes annual mean concentrations and standard deviation ($\mu g \cdot L^{-1}$)

Lake	Year	Depth	Al	Cu	Fe	Mn	Zn
260	1986	Epi	5.5± 3.0		57.0±56.8	6.0± 7.1	3.4±1.5
382	1986	Epi	17.3± 8.5		10.4± 5.2	1.5± 1.4	2.4±2.6
303	1981	OF	40.1±21.8	1.1±1.1	25.1±16.8	10.3±11.8	2.8±2.5
	1982	OF	32.0±11.8	1.7±1.4	33.8±24.4	12.6±14.9	2.4±0.9
240	1981	Epi	14.8±10.1	1.5±1.3	22.4±19.9	4.5± 9.2	1.5±1.3
	1982	Epi	14.8± 4.1	1.4±0.7	25.1±10.5	3.4± 5.6	1.8±2.0
	1983	Epi	9.2± 4.3	1.5±0.6	13.0± 8.5	1.2± 2.1	1.2±0.8
	1984	Epi	8.7± 3.5	1.1±0.5	15.9±18.9	2.1± 2.2	2.1±2.1
225	1984	Epi	106.1±27.7	1.0±0.6	25.5±27.1	17.5± 5.6	4.1±3.8
	1985	Epi	181.8±25.2		119.4±27.2	24.7± 3.8	8.8±7.7
	1986	Epi	185.5±72.3		121.9± 113	22.5± 6.6	10.6±9.6
224	1977	1	9.5± 7.2	1.1±1.3	7.5± 6.6	2.7± 3.7	3.3±2.1
	1977	5	5.4± 4.6	0.9±0.7	6.9± 6.4	1.8± 1.6	3.1±2.1
	1977	10	3.5± 1.0	1.5±2.7	13.3±15.9	1.9± 1.8	3.4±2.1
	1977	20	5.1± 2.4	1.6±2.0	24.2±26.1	17.2±18.9	4.1±2.0
	1977	25	7.9± 5.6	0.9±0.9	39.1±35.0	52.5±41.3	3.9±1.1

Table 7. Summary of quality control waters analysed with each set of concentrated ELA waters by DCP.

	Metal ($\mu g \cdot L^{-1}$)				
	Cu	Zn	Mn	Fe	Al
Batch 1 analysed October-November 1982					
N	8	8	8	8	8
Mean	22.1	20.9	23.0	51.4	56.2
Standard deviation	1.2	0.49	0.65	5.1	4.2
Target concentration	20	20	25	50	50
Batch 2 analysed December 1983-September 1983					
N	27	27	27	27	27
Mean	16.4	11.0	22.9	51.2	47.1
Standard deviation	1.4	0.82	1.3	3.2	10.2
Target concentration	20	10	25	50	50
Batch 3 analysed September 1983-July 1984					
N	30	30	30	30	30
Mean	10.3	10.8	46.6	104	103
Standard deviation	0.73	0.89	2.7	6.9	4.6
Target concentration	10	10	50	100	100
Batch 4 analysed September-December 1984					
N	22	22	22	22	22
Mean	4.9	4.9	21.8	50.1	27.5
Standard deviation	0.54	0.63	1.8	5.3	4.8
Target concentration	5	5	25	50	25

Table 8. Quality control water analysed by graphite furnace (direct injection).

	Metal ($\mu g \cdot L^{-1}$)				
	Cu	Zn	Mn	Fe	Al
Batch 4 analysed September 1984-May 1986					
N	25	30	16	17	20
Mean	4.6	5.0	24.9	48.6	27.2
Standard deviation	0.2	1.0	2.05	2.3	2.2
Target concentration	5	5	25	50	25
SLRS-1 analysed July 1986-March 1987					
N	5	16	7	10	19
Mean	3.7	0.80	1.2	35.5	24.4
Standard deviation	0.41	0.29	0.59	2.7	2.4
Published value	3.58	1.34	1.77	31.5	23.5
95% tolerance limits	0.3	0.2	0.23	2.1	1.2

Table 9. LRTAP inter-laboratory study no. L-13 (total aluminum in water).

	A1*	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11
Series A - unpreserved aluminum ($\mu g \cdot L^{-1}$)											
FWI reported value	0.4	9.0	45	56	101	127	135	225	307	440	353
Total labs reporting	21	21	21	21	21	21	21	21	21	21	21
Total labs used	9	13	20	19	21	20	20	20	21	21	21
Mean	0.93	12.1	45.5	63.8	93.3	126.2	132.2	194.8	285.8	377.7	344.4
Standard deviation	9.4	13.6	17.5	24.8	22.8	28.1	33.0	37.9	61.9	97.6	83.8
Median	3.0	8.0	44.4	55.0	91.0	128.5	135.0	208.5	307.0	410.0	353.0

	B1	B2	B3	B4	B5
Series B - unpreserved aluminum ($\mu g \cdot L^{-1}$)					
FWI reported value	140	228	311	431	349
Total labs reporting	15	15	15	15	15
Total labs used	15	15	15	15	15
Mean	125.8	204.3	298.8	387.0	348.3
Standard deviation	21.9	25.1	32.6	60.4	40.9
Median	132	210	305	397	362

	C1	C2	C3	C4	C5	C6
Series C - preserved (HNO_3) aluminum ($\mu g \cdot L^{-1}$)						
FWI reported value	0.5	49	99	407	250	284
Total labs reporting	22	22	22	22	22	22
Total labs used	8	21	22	22	22	22
Mean	9.6	54.0	97.3	344.6	257.6	286.9
Standard deviation	14.3	8.2	13.0	100.1	50.6	51.7
Median	3.4	53.0	98.0	387.0	255.5	293.0
Target concentration	0	50	100	400		

* Distilled water blanks.

Table 10. Assessment of metal contamination introduced by filtration using distilled deionized water as a simulated lake water sample.

		Metal ($\mu g \cdot L^{-1}$)				
		Al	Cu	Fe	Mn	Zn
Mar 16, 1983	acidified	1.2	<0.5	<5	<0.5	<0.1
	filtered and acidified	1.0	<0.5	<5	<0.5	<0.1
Oct 26, 1983	acidified	2.4	<0.5	<5	<0.5	0.2
	filtered and acidified	2.2	<0.5	<5	<0.5	0.4
Mar 7, 1984	acidified	1.5	0.6	<5	<0.5	1.3
	filtered and acidified	2.1	1.4	<5	<0.5	0.6
Jan 25, 1985	acidified	<0.5	<0.5	<5	<0.5	0.1
	filtered and acidified	<0.5	1.1	<5	<0.5	0.1
June 28, 1985	acidified	<0.5	NA[1]	<5	0.5	<0.1
	filtered and acidified	<0.5	NA	<5	0.7	<0.1
Nov 1, 1985	acidified	<0.5	NA	<5	<0.5	0.6
	filtered and acidified	<0.5	NA	<5	<0.5	3.4
July 3, 1986	acidified	1.4	NA	<5	<0.5	0.5
	filtered and acidified	1.8	NA	13	<0.5	5.5
Sept 12, 1986	acidified	0.5	NA	<5	0.6	0.1
	filtered and acidified	<0.5	NA	<5	0.7	0.6
Oct 6, 1986	acidified	<0.6	NA	<5	<0.5	0.2
	filtered and acidified	<0.7	NA	<5	<0.5	1.0

[1] NA - not analysed

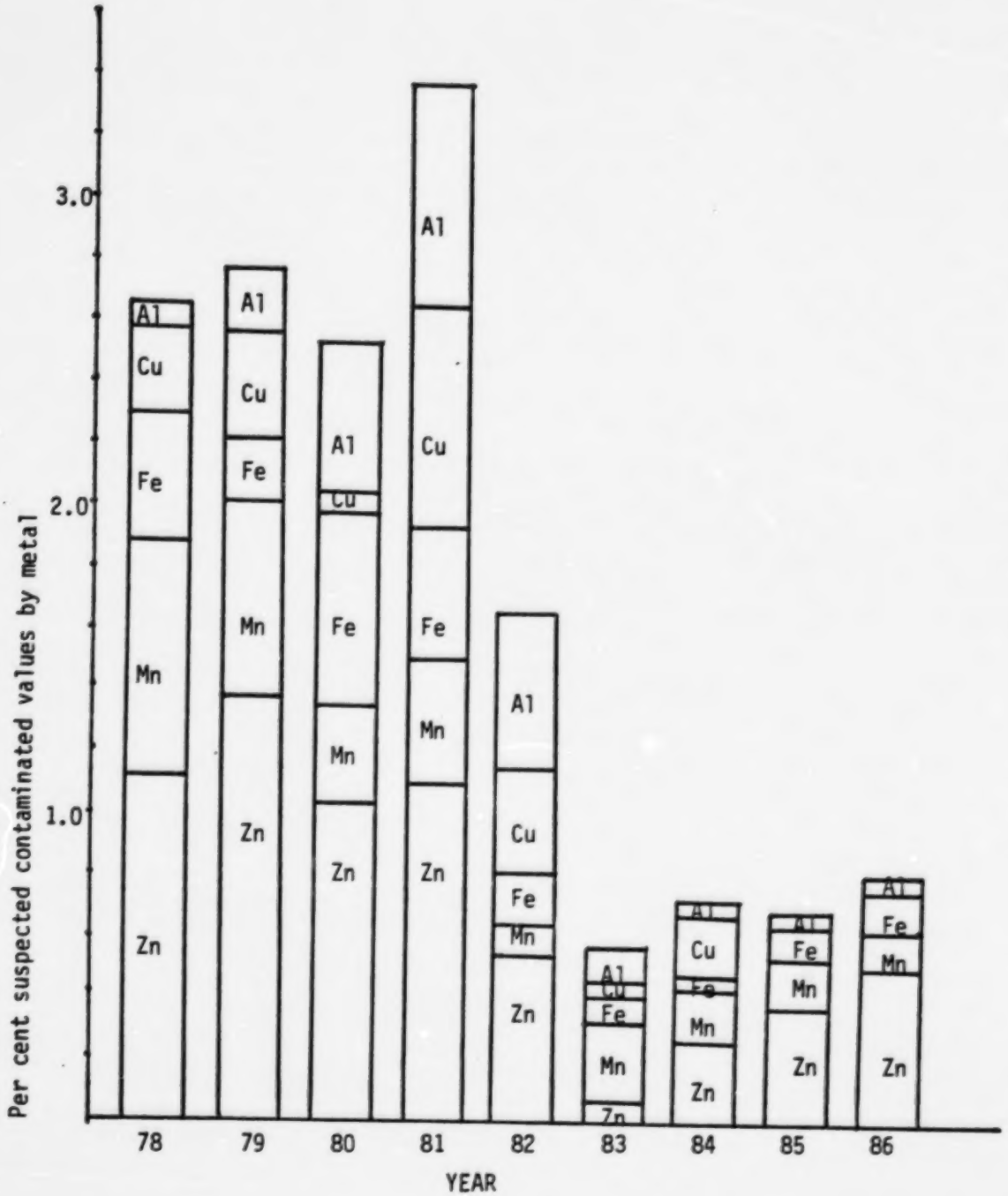

Fig. 1. Per cent suspected contaminated values eliminated from each year of data.

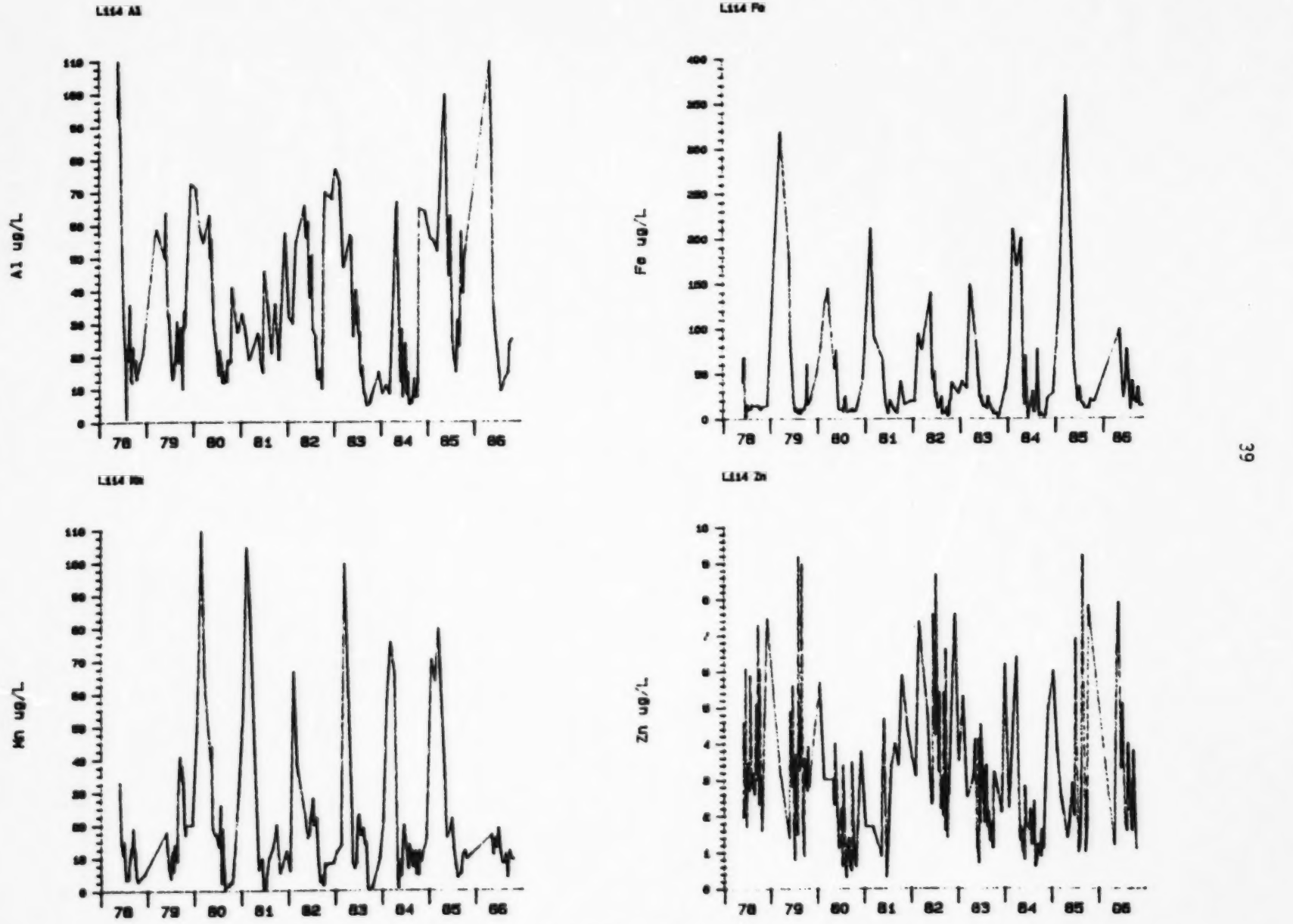

Fig. 2. Concentrations of Al, Fe, Mn, Zn at 1 m in L114.

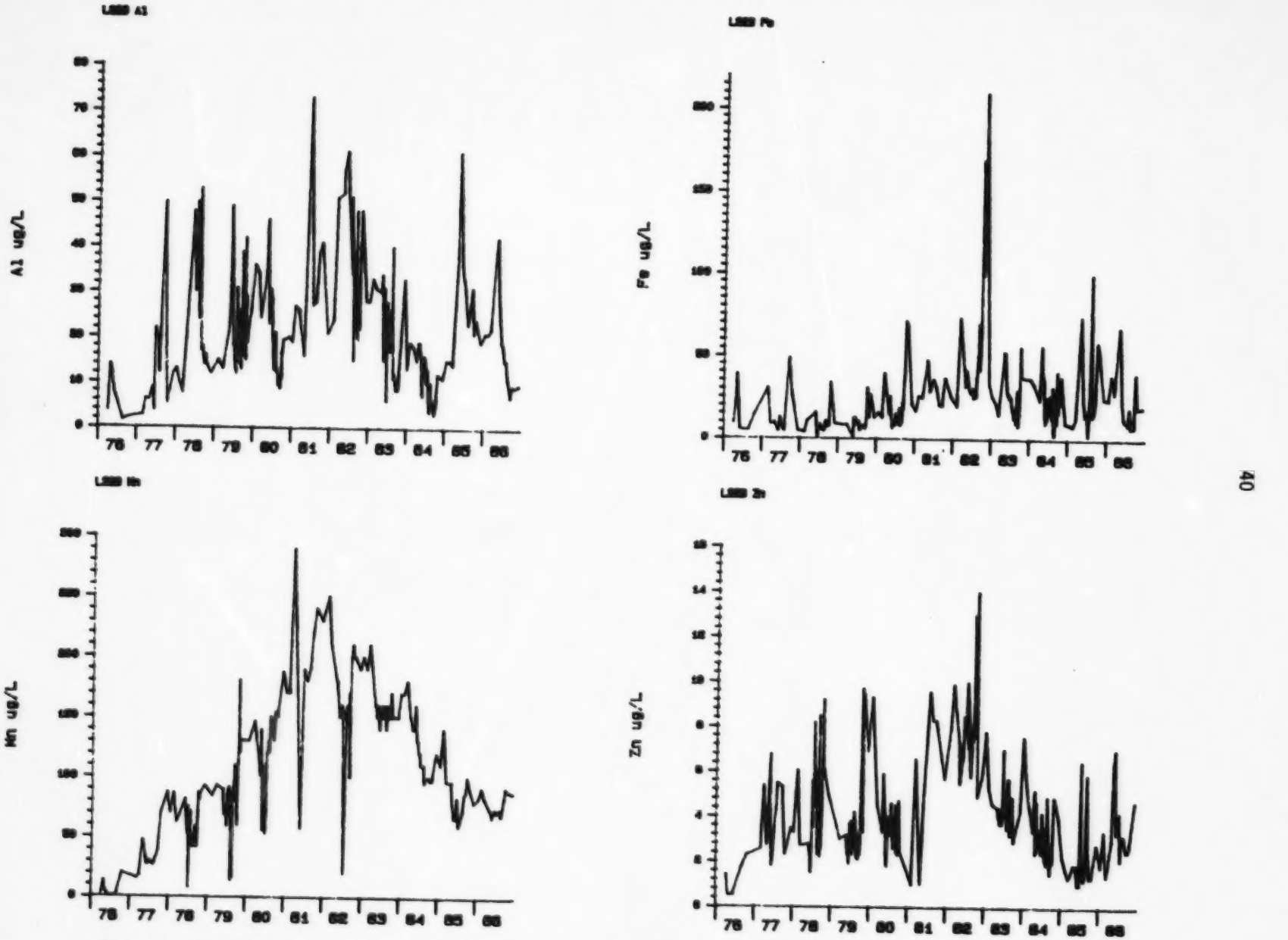

Fig. 3. Concentrations of Al, Fe, Mn, Zn at 1 M in L223.

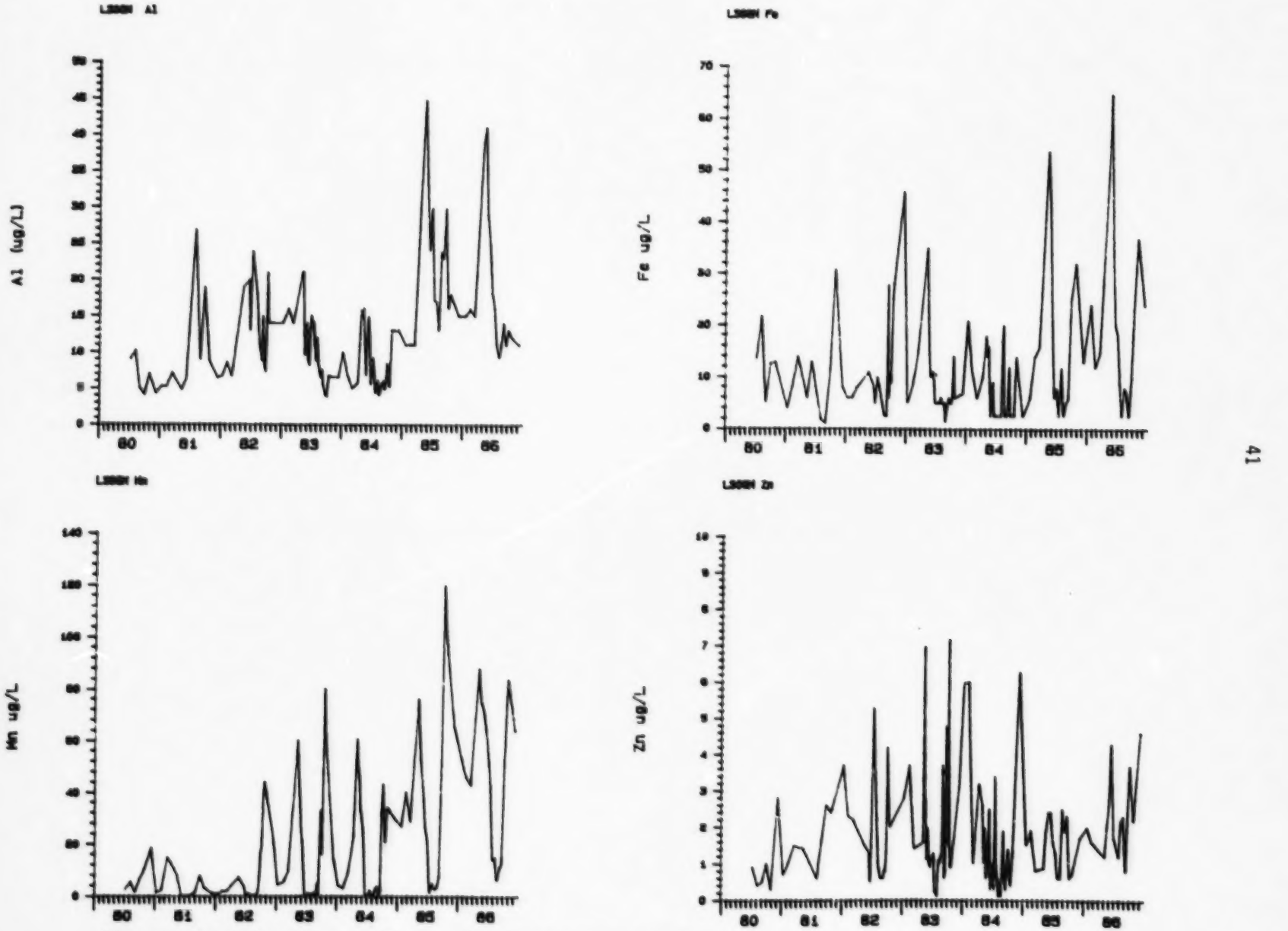

Fig. 4. Concentrations of Al, Fe, Mn, Zn at 1 m in L302N.

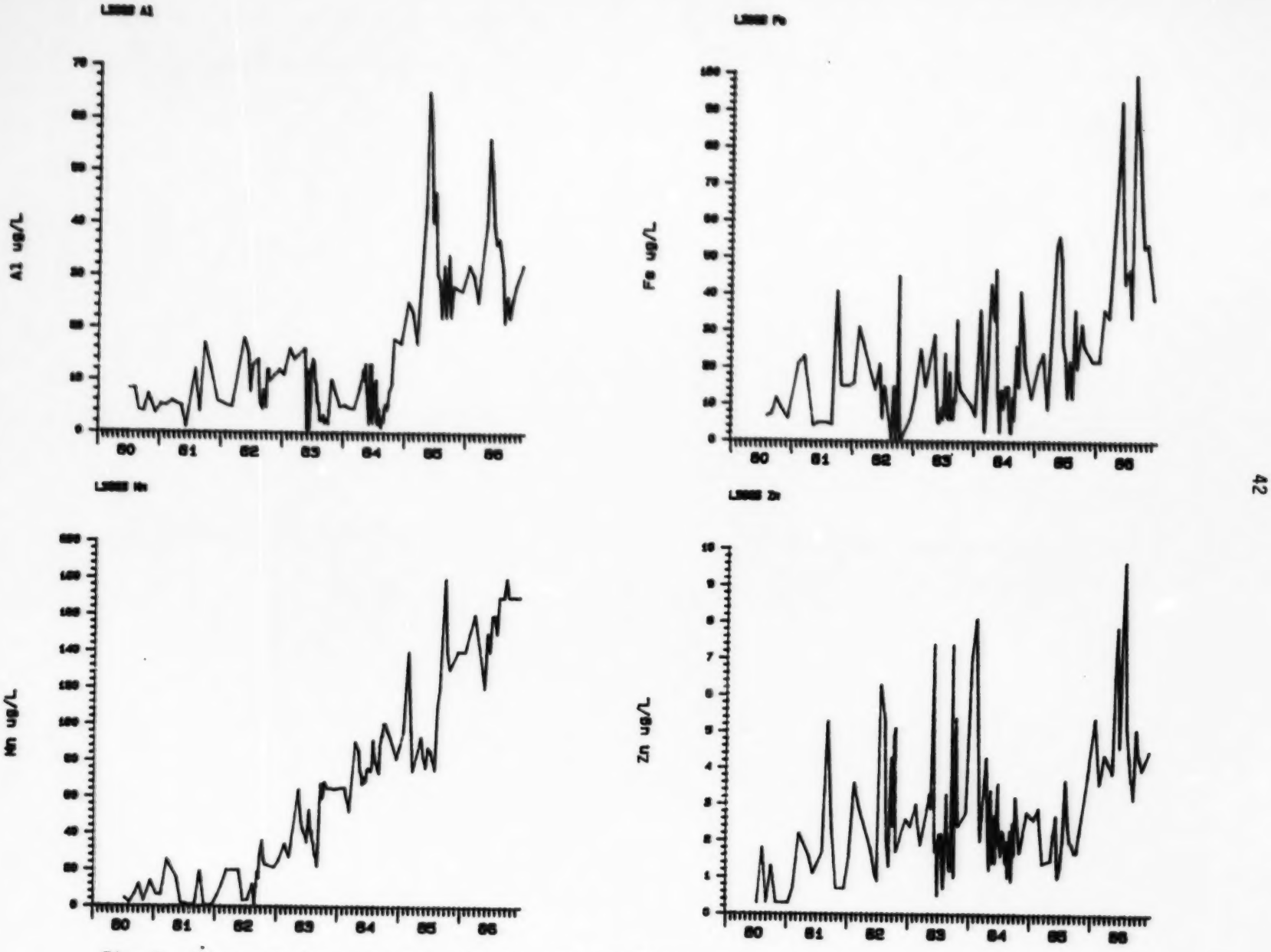

Fig. 5. Concentrations of Al, Fe, Mn, Zn at 1 m in L302S.

APPENDIX 1

Aluminum Raw Data

● Values with a solid dot were considered to be contaminated analyses and were not included in any calculations